Spring 3-1899

Volume 8 - Issue 6 - March, 1899

Rose Technic Staff
Rose-Hulman Institute of Technology

// THE ROSE TECHNIC.

VOL. VIII. TERRE HAUTE, IND., MARCH, 1899. No. 6.

THE TECHNIC.

TERMS:

One Year, $1.00. Single Copies, 15 Cents.

Issued Monthly at the Rose Polytechnic Institute.

Entered at the Post Office, Terre Haute, Ind., as second-class mail matter.

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THE Freshmen, having completed the first two term's work in common, will now be required to select one of the prescribed courses of study. In nearly every class there are some students who permit themselves to drift with the rest rather than investigate the essential differences of the courses. This some times leads to a great mistake, found only too late. It is every man's duty to himself to thoroughly investigate the five courses offered and to personally visit each department and see the nature of the work being performed by the class in that department. It is his duty to select according to individual taste, if such be evident, or if his future may by circumstance be partially outlined, he should prepare himself to best meet its requirements.

THE first of the course of lectures upon general engineering topics was delivered on Thursday, the 16th, by Mr. F. E. Bausch of St. Louis, for a long time chief engineer for the St. Louis Telephone Exchange, but now with the Missouri Edison Electric Company. The subject of Mr. Bausch's lecture was "Telephony and a Modern Telephone Exchange." The history of telephony was briefly traced, and the rapid advancement from a scientific toy to the requisite of every place of business in a large city was reviewed.

The telephone industry has now reached such vast proportions that over a million and a half instruments are in daily use, not only in local lines connecting places a few miles distant, but the improvement in the art of transmission of articulate sounds by means of electricity has reached such a degree of perfection that now communication may be had over the long distance lines for hundreds of miles.

A description of a modern exchange, with its complicated and colossal switch boards requiring millions of feet of wire for its connections, and its almost automatic operation, clearly shows the great advancement that has been made in the last quarter of a century, or in even less time, in the application of a scientific principle to the comfort and convenience of humanity.

With this ever increasing demand for improvement and application of existing scientific principles comes an equal demand for higher and more thoroughly educated men to take charge and operate the complicated machinery of to-day. The engineer of the next century will be brought face to face with problems of such proportions that his utmost ability and skill will be taxed to its limit, and his place in the industrial work will no longer be only a factor, but he will be a power and necessity.

THE Council has become a reality and the financial question has found a solution which from the present point of view meets every requirement. The problem of finances is one of the most embarrassing and perplexing questions which must be met in every college where there are a number of organizations that require the support of the student body for their promotion. With this problem solved and the way clear for greater usefulness and a rapid advancement and extension of the various organizations, comes another question of vital importance. Will the student body enter into the life and work of the organizations with that vigor and determination that is necessary for a successful attainment of the several objects which the organizations represent? Can the interest and enthusiasm which has been shown in the promotion and realization of this plan, of united support financially, be counted upon in the perfecting of the organizations? Before this change was adopted there was a continual cry of lack of means to carry on the work, but now that the means have been provided are the men ready to enter into the work and obtain that good which will come from a united effort on the part of all? This remains to be seen and should have a fair trial in order that the restless spirit which has prevailed for so long may wear off. Radical changes need not be expected at once, as only time can erase what time has already produced. The future of the organizations were never so bright and the opportunity for a successful change was never more encouraging. Each student owes it, primarily, to himself to enter into every college enterprise and throw his individual talent and power into the furtherance of the many objects which college organizations represent. By so doing he not only gives himself a chance to expand and broaden, but he shares his talents with others and both are benefited, the one by the ability to use his gifts and to strengthen his powers by application, while the other is broadened by coming into contact with the thoughts and talent of some one else.

THE Council made two recommendations to the Athletic Association in regard to their finances that met with disfavor through a misunderstanding of the attitude of the Council and the relation of the Council to the student body. The Council does not possess executive power, but only assumes legislative power in considering and making recommendations to the student body, who possess the true executive power.

In the recommendation to the Board of Directors that members of the Association be admitted free to all games played on the campus, the Council had several reasons. First, the student body, as such and individually, are contributing a large sum to the support of the Association, much more than they have ever had before; the concessions which the Association will be able to make to the students, are far in arrears of the amount that is now being contributed, unless the students be granted all of the privileges of the grounds. Certainly this is asking little, when the attendance for the last year upon the games is taken into consideration. Perhaps with this plan the attendance will be increased, and certainly the enthusiasm will be greatly increased. Secondly, the entire student body has become the membership of the Association and have been granted all the privileges. As there are no rules prohibiting other athletic sports being carried on during a game, each student can demand as one of his rights the privilege of the grounds at all times. These are his rights by virtue of his membership and payment of his dues. This may reduce the gate receipts somewhat and the income of the Association, but the small loss which this concession will produce, when compared with the support which will be received from the individuals and the additional enthusiasm and interest which will be created, should more than counterbalance the decrease in the funds. If it is seen that the Association will not be able to meet its obligations without increased gate receipts, then the students will be willing to pay their admission in order to help the Association, but not otherwise.

A second recommendation was made to the Board which met with a decided opposition, and shows a very narrow and selfish spirit in the management. The resolution which has just been adopted creating the "Students Fund" provides, "that this money is to be paid to the various organizations as their expenses demand until their quota has been reached."

The Council recommended to the Association that it incorporate in its by-laws the clause, "So long as the treasury has sufficient funds arising from gate receipts or other sources, the quota of the 'Student Fund' can not be drawn upon."

This has been objected to on the grounds that the gate receipts are the individual resources of the Association and should be used as they desire, and that the quota of the "Student Fund" should be used to pay all running expenses while this income from outside sources is reserved for special objects.

This additional income is certainly the individual resource of the Athletic Association and can not be used for any other purpose, but so is the "Student Fund" the fund of the student body to be used to promote the welfare of all the organizations. The Council does not intend under any circumstances to give any support or allow the quota to be drawn upon by any organization unless it is actually needed. This money has been placed in the hands of the Council to promote the interests of all and will be so used to the best of their ability. This is a selfish view of the matter as taken by the Association, and no doubt comes from a misunderstanding of the object of the Council which is first and above all to use its influence to promote a strong college spirit, and secondly to keep college politics clean, and establish the organizations on a strong foundation, and provide for their future welfare. With these objects in view the present plan of finances was proposed and adopted by the students. Certainly if one organization is going to be allowed to draw on the "Student Fund" for its running expenses and at the same time be receiving an income from outside sources, to be used as it may choose, the real object of the Council will be defeated and the plan of a "Student Fund" will be a failure. The Council does not desire to have control of this income, nor will it dictate how it shall be used, but so long as this money is idle the expenses of the Association cannot necessitate the quota being drawn upon. There is no doubt but that the Association will require all of the income and the quota to meet its obligations and perhaps more, but the funds on hand should be used first and then the "Student Fund" drawn upon.

Each organization is under obligations to make the best possible use of its resources, for the good of all, and should not let a selfish spirit of self-advancement cause it to forget that it is but one of several organizations that have been founded and are supported for the good which the individual and school will obtain from a judicious exercise of the powers which have been granted.

A SOLUTION has been reached, we hope, for the financial condition and support of the various organizations. With the new plan of general membership we hope that the success of each organization will be assured and are confident that the future prosperity has been placed on a strong footing.

With this change in the financial condition comes a necessary change in the administration of the various organizations.

New methods of government will have to be inaugurated and the constitutions of the various organizations will have to be amended to meet the increased demands made by the larger membership and the possible extension of the field of usefulness. Notably among the organizations that will have to re-organize and branch out is the Athletic Association. In the past, with only a limited membership the existing constitution, by-laws and rules governing the use of property, were in a measure adequate and covered the ground sufficiently well to meet most of the demands. But now that the membership has been increased to the entire school and the income has been greatly supplemented, new duties and obligations have been imposed that will require wise legislation to successfully meet. The control and management of the gymnasium has been placed in the hands of the Athletic Association and will now require careful supervision in order to protect the property and provide opportunity for all to enjoy the privileges which their membership grants. One of the foremost considerations is the government; if it were possible to provide an instructor, who could devote his entire time to the work in the gymnasium, the matter could be easily solved by making him personally responsible for the oversight of the athletic property, but this is out of the question at present for financial reasons, and a substitute will have to be found. The only alternative is to obtain a director who will take charge of the classes and coach the teams, being present at specified hours. With this arrangement a great deal of good will be done and the individuals will receive almost as much benefit as if the director spent his entire time in the gymnasium. But the care of the Athletic Association's property and interests must rest in the hands of the directors, and they will have to provide some plan by which the government of the gymnasium may be directly under their control. The Council submitted a plan which will be entirely satisfastory, provided the classes will elect their directors for their ability and willingness to perform their duty, and not because of political influence. The plan suggested consists briefly in this: Two or more directors shall be elected from each class and shall compose the Board of Athletic Directors; the Board of Directors shall appoint one or more of the directors to have charge of the gymnasium and athletic grounds each day of the school week. They shall be given authority to enforce the rules and regulations of the gymnasium and athletic grounds and shall be held personally responsible to the Association, through the Board of Directors, for the property and apparatus under their charge. The directors in charge of the gymnasium shall be at all times during their specified supervision in the gymnasium, or on the grounds, where they can be found and can look after the duties assigned. With an arrangement of this nature the grounds and gymnasium will be constantly under the care of the board and all property lost or injured can be accounted for.

By having two or perhaps three directors from each class, the tax upon any one will not be great, as the hours when the gymnasium or grounds can be used are limited. By appointing one director to have charge in the morning and another in the afternoon, the demands made upon the time of any one will not be excessive, as the hours when it is possible for members of any class to be present is easily determined from the hour plan. On some days the director will not be required to spend over an hour in the gymnasium, on others perhaps two or three. Saturday afternoon will be the longest time that any one will be required to be on duty, and this can be divided. By furnishing the directors room so that it can be used as a study room, the director can occupy his time in any way he chooses, so long as he is present in the building. The property and all apparatus will be directly under his care and he will be required to issue it in person, so as to be held responsible.

With this plan the supervision can be systematized and the minimum demands made upon any officer. Of course, the directors will have to be conscientious men, who are willing to sacrifice a little personal comfort for the good that will be done. But by electing only those who will faithfully perform their duties and who can be depended on, the matter can be adjusted tot he satisfaction of all. Failure to perform reasonable duties should be at once punished by expulsion from office and a few cases of this will soon make the men realize that if they accept an office they shall fullfil the duties or must give up the position to one who will.

Where the success of any enterprise is based on the support and co-operation of the individual members, each one should consider it his duty to do his part to the best of his ability. This is the plan upon which all school organizations are founded, and the success of the whole depends entirely on the enthusiasm and conscientious support of each one. The greater part of the burden must naturally fall on a few, as leaders are always necessary, and they must be willing to sacrifice, often, time and personal interests in order to carry out the obligations that they have assumed by accepting the office. Any office that is worth holding requires time and thought, and would not be worth considering if such were not the case, so the officer must expect to devote some of his time to the promotion of the enterprise, in which he has assumed a share of the responsibility.

"Boilers and Furnaces Considered in their Relation to Steam Engineering." By William M. Barr, M. Am. Soc M.E.; Philadelphia; J. B. Lippincott Co.; cloth, 8 vo.; pp. 405; illustrations 468; $3.00.

THIS work superceding "High Pressure Steam Boilers," (1880) by the same author, constitutes Volume I of a new steam series, and treats only of stationary boilers and furnaces, and from the standpoint of the builder or designer rather than that of the boiler user. It will be, perhaps, of more value to students and younger men of the profession than to older engineers, in that it contains nothing exceptionally new, but is rather a systematized compilation of generally accepted facts and formulas relating to boiler design and construction.

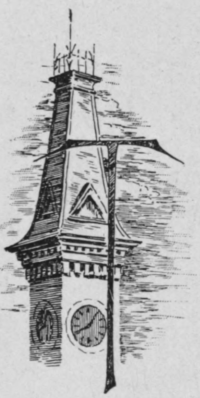
Chapter I discusses the various fuels used in boiler furnaces, and calculations are made for heating power, etc. In the author's assumptions the practical values employed by engineers are used and Dr. Tances' old value of 772 foot pounds is taken for the mechanical equivalent of heat, instead 778, which is probably a better value.

In Chapter II the materials of boiler construction are described and the requirements for commercial tests cited. Chapter III, of 45 pages, treats of riveted joints, and is of especial value. It is fully illustrated and contains the results of several tests made at Watertown Arsenal. In the next 90 pages welding and flanging are considered and there is a discussion of the details and strength of construction. The latter is very complete, and contains extracts from the rules of the U. S. Board of Inspectors regulating pressure, thickness of metal, dimensions of flues, staying, etc. Chapter VI describes externally fired boilers. Chapter VII is devoted to furnaces and boiler settings. Various mechanical stokers are illustrated and their results set forth. After this, internally fired, sectional and water tube boilers are taken up. Chapter X is descriptive of boiler mountings and safety appliances. Here, also, reference is made to the United States and Philadelphia regulations. In the author's treatment of chimneys, Chapter XI, "Only the necessary dimensions of diameter and height for boiler plants from 20 to 1000 H. P." are given, since he wishes to consider the subject at greater length in a separate volume which is to be published soon.

Taken as a whole, the book is very interesting and very useful and should find a place with any engineer, especially one engaged in designing. The first recommendation for the book is that the author has not attempted to crowd too much into one volume, which makes the subject more interesting and lends an interest and anticipation to the volumes that are to follow. Marine engines and locomotive engines are to be treated in two separate volumes in this series, and have, therefore, been purposely omitted in the present one. The typographical work is fine and the illustrations are remarkably above the average.

Architectural Drawing.

PROFESSOR O. E. McMEANS.



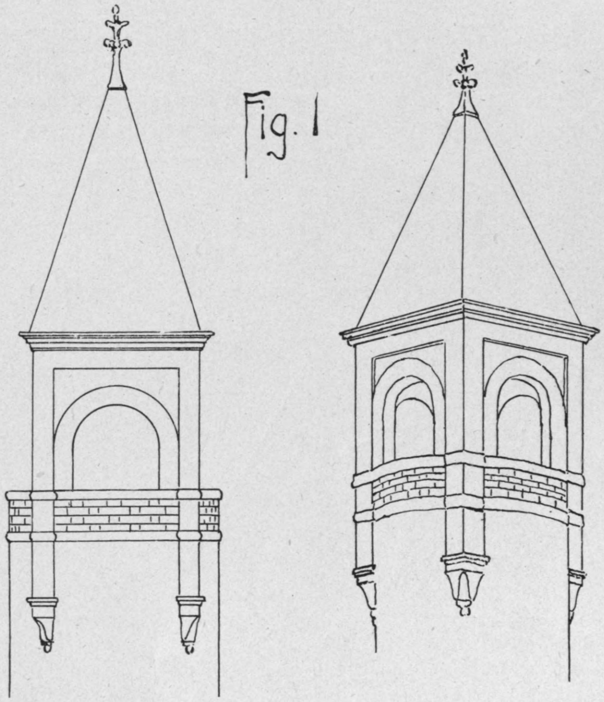
THE ability to make good drawings, and make them readily, is as essential to the young architect or the draughtsman who hopes some day to add "Arch't" to his signature, as is the power of fluent speech-making to the young attorney. To the older man, with a well established practice and reputation, comes the possibility of leaving to subordinates the placing of the master's ideas upon paper. The young man must not only do his own thinking, but must himself make the record of his thoughts. This record, in the form of drawings, is a great factor in his success as a designer of buildings. Not that pretty drawings are in any sense the aim or end of architectural study. The architect is first of all a designer in wood, brick, stone, and iron. His reputation will always rest upon the comforts and conveniences which his buildings possess, upon the beauty and fitness of their ornamentation, and the wise selection and economy of material. His knowledge of the time-tried laws of harmony in proportion, of safety in construction, of beauty in decoration, and his familiarity with the uses of materials, old and new, as shown in the practice of the various building trades, may one or all be worth more to him than his skill in making drawings. But nevertheless drawings play so great a part in fixing the designer's ideas for himself and in imparting them to others, that they become of the greatest importance as means to an end. It is the purpose here to discuss briefly some points concerned in their making.

In the study or practice of architecture, the sharp distinction usually made between freehand and mechanical drawing does not maintain itself. The T-square, triangle, and scale are aids to the draughtsman's eye and hand rather than his sole dependance. He is concerned very largely with the appearance of things. The dimensions of the parts shown on his working drawings are determined about as often by considering how they will look as by any calculation of strength or other test of fitness. A great facility in making of small pencil sketches from the object or from imagination will be of much advantage and should be cultivated. The lead pencil is the draughtsman's chief means of expression. Water colors, pen and ink, crayon, or charcoal, may be found in the draughting room to be used on occasion, but the lead pencil should be in the draughtsman's pocket when it is not in his hand. With it he should be more ready at expressing his ideas than he is with his tongue.

Sooner or later every draughtsman becomes thoroughly aware of the fact that the plan, front elevation, side elevations, or any projection in fact, is by no means a sufficient guide to the appearance of a building or any detail of it when seen in solid form. There are indeed some details of construction and more especially of ornament of which drawings of any sort fail utterly to convey the whole idea. Carving is a notable example. In this case the only certain medium for the expression of the designer's intention is the modeling clay or wax. Many other parts other than carving may, with profit very often, be modeled before being drawn at least; but it is not the purpose here to treat of modeling, but drawing.

Next to the model in relief, the best means for determining the appearance of any object is perhaps the carefully made perspective drawing. The subject of perspective is generally considered as of greatest use in making pictures for the edification of prospective owners of buildings. It has, however, a larger and it may be well to style it, a more legitimate field of usefulness. This lies in the way of helping the draughtsman to a more perfect conception of what his plans and elevations will look like when executed in brick and stone. For this purpose a mere smattering of the laws of perspective, of course, will not do. A fairly thorough understanding of the theory of the subject is necessary. This for two reasons: first, that the drawing may give what is wanted, a reliable test of the appearance of the structure as seen from some certain standpoint; and second, that too much time may not be spent in drawing it. Perspective drawings for this purpose will very often not be inked in or finished up at all. The pencil outline will be sufficient to satisfy the designer as to the good or ill success of his proportions. In the latter event, with an accurate perspective, the proper changes to secure an harmonious appearance may be made upon it first and then transferred to the working drawings with perfect assurance as to the result.

Such a procedure may be called "designing in perspective" and may be applied with benefit to the most simple of structures in which appearance is to any degree important. The process will, in many cases, be something as follows: First, lay out the main lines in perspective, then make upon these as a basis a free-hand sketch giving the desired appearance, finally true up the sketch somewhat with the instruments and determine the sizes of parts to be applied on plans and elevations. Each particular building to which such a method of design is applied will develop features showing the advantage arising from considering the desired appearance first, the real dimensions afterward. In the case of turned objects, such as posts or balusters, the relation of the round parts to the square ends as seen on the working drawing is very misleading. The same sort of combination is met with in designing a



square top for a round tower, as shown in Fig. 1. The draughtsman who neglects to make a perspective sketch of such a feature before fixing the dimensions, may consider himself fortunate if the appearance comes anywhere "within gunshot" of what he had in mind. The appearance of a pitched roof will generally be found vastly different on elevations and perspective drawing. The latter will show hips and roof surfaces flatter and gables sharper than the elevations. This difference will, in the case of the roof of a tower, sometimes make necessary an increase of one-third of the height over what the elevations would show as desirable. These effects and others may be noticed by comparison of Fig. 2 and Fig. 3, and of the two sketches in Fig. 1.

As has been stated, the perspective in simple line will in general serve the purpose of the designer. However, the application of shades and shadows in pen and ink, wash, or other medium, may be done with almost as great accuracy as in the drawing of the outlines. A much greater degree of artistic skill is required on the part of the draughtsman, based upon observation and experience in sketching from the object. With careful work and strict adherence to the truth in the rendering, the only limit to the accuracy of the drawing is that of a photograph made from the building after erection. It is a very easy matter for the maker of the drawing to exaggerate the effects of light and shade beyond what he knows would be the effects of the forms used. This may be pushed to the point of making a tame or flat design seem to be bold and full of life. It is for this reason that perspective drawings submitted in competition for important buildings are usually required to be in simple line with no shading whatever.

Fig. 2.

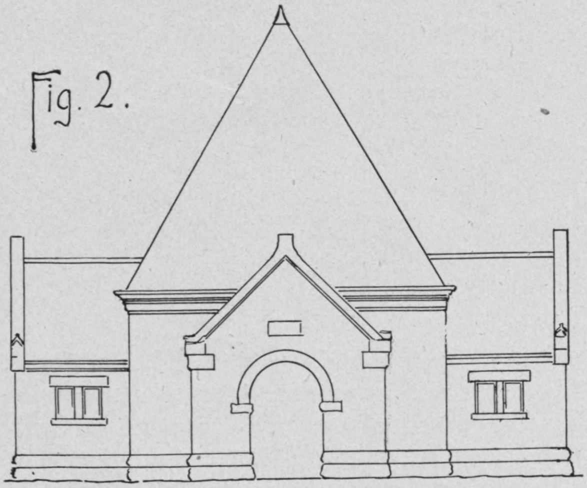
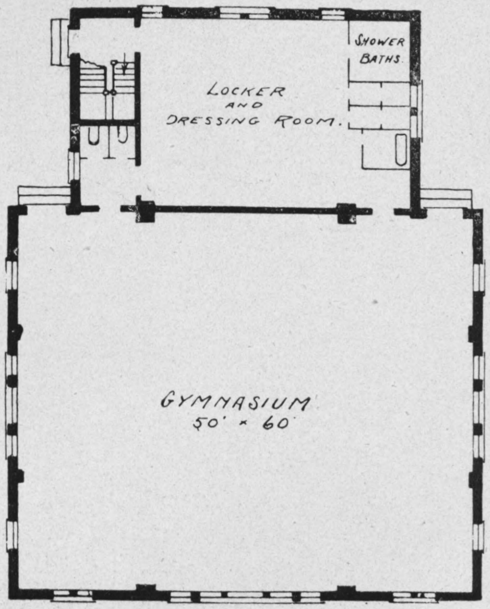


Fig. 3.

The working drawings or "plans" for a building being simply orthographic projections, involve no essentially different principles in the making from those used in the case of working drawings for any other purpose. The principal floor plans, being what may be called horizontal sections at the level of the windows, are usually laid out first. In doing this the designer keeps in mind the desired external appearance, but this is made subordinate to the convenience of the interior and to logical and safe construction. These relations are often reversed and the plans made to fit some nice scheme for an exterior. This is generally evident from the ill-shaped rooms, awkward or dark corridors, or even worse incongruities. The neat appearance of the building as seen from across the street is not very apt to reconcile the owner to unpleasant daily contact with such an interior.

The floor plans outlined, the elevations or vertical projections are laid out. The new elements which enter here are the heights of stories, of windows and doors, the pitch and character of roof, the design of cornice, and other purely external features. Many slight changes in the position of doors or windows, in the arrangement of the roof, or in the general treatment of the exterior may be made if a better exterior appearance is thereby secured. Right here is where "designing in perspective," as previously mentioned, comes in. In a large building, one or more vertical sections may be found necessary to properly show the stairways, different floor levels, or other matters of design or construction not evident from the plans or elevations. The last of the general drawings to be made are usually the foundation plan and roof plan. The former shows the location of the walls and piers necessary to support the building, the latter the main lines of the roof surfaces which are to cover it. All the drawings mentioned must to some extent be carried along together, as any changes in one are pretty sure to require corresponding changes in some or all of the others.

In all this work the draughtsman must necessarily have his descriptive geometry at his fingers' ends. He learns to think not so much of the process as of the results, very often inventing special methods or short cuts to suit certain



FIRST FLOOR PLAN

problems. He sees the solid object behind the projections rather than the projection as representing the object. From the constant use of certain scales, such as the one-quarter inch, one-eighth inch, and three-quarter inch, he learns not only to think in projection, but to scale. Certain standard dimensions, such as thickness of walls and widths of door and window openings, become so familiar that any error in laying them out is at once apparent to him.

The making of detail drawings comes last. These are drawings to a larger scale showing interior and exterior parts with much more exactness than can be done on the general drawings. Plans, elevations, and sections of the parts are used, usually all relating to one part or detail being on one sheet. The making of detail drawings requires a very accurate knowledge of building practice, and of the sizes and properties of materials.

The process of blue printing or copying drawings by means of sensitized paper exposed to sunlight, has revolutionized methods of finishing architectural drawings in the last fifteen years. The principal drawings are now commonly made on cheap manilla paper and are not inked on the paper at all. A tracing of each drawing is made on the best quality of tracing linen and this constitutes the original drawing kept on file in the office. Any number of copies of this tracing can be made by blue printing and are sure to be exact fac similes, errors and all.

Modern Ordnance.

CLARENCE H. TUCKER, '97.

THE development of gun-making, like that of electrical machinery, will fill an important chapter in any volume describing the progress of science during the last part of the present century.

The Washington Navy Yard affords an excellent comparison of the old and new in gun construction. On entering, one passes a few historic brass cannon, captured from the enemy during our early wars, and later is able to compare with these ancient pieces of ordnance a modern high-power rifle, composed of tons of open-hearth steel, representing in its construction the finest mechanical skill, and embodying in its design the results of much scientific research.

The design and use of modern implements of war involve problems in every branch of the engineering sciences, and present many examples of the application of theory to practice, a few of which I will attempt, in a general way only, to describe.

The gun used to-day in both our army and navy is of the built-up type. A built-up gun comprises a long central "tube," upon which are shrunk rows of outer cylinders or hoops, until we have, depending upon the caliber of the gun, from one to three rows of cylinders superimposed upon the tube.

The accepted theory of this mode of construction is so to assemble the several rows of cylinders, that during firing the maximum fibre stresses in all shall be equal and that in whatever state, (that of actual firing or of rest) none of the fibres in any cylinder are stretched beyond their respective elastic limits. The distortion in a state of rest is due, of course, to the compression which the tube suffers from the shrinkage of the assembled cylinders.

Much credit may be given to Capt. Rogers Birnie, Jr., Ordnance Department, U. S. A., for the early development and rational arrangement of the formulæ relating to the design and proper shrinkage for this construction. Abroad, the investigations of Major Clavarino, of the Italian army, and the excellent works of Colonel Virgile, of the French artillery added much to the development of the theory.

The term "shrinkage" applies to the amount by which the outside of the tube is turned larger than the bore of the jacket or hoop that is to be shrunk upon it.

The hoop is first bored out to size, and then "star-gauged" at every inch or so in its length, the readings showing (in thousanths of an inch) the variations — plus or minus — from the standard diameter. The tube is then turned to correspond to the bore, that is, to a diameter equal at every point to the diameter in the bore at that point, plus the amount of shrinkage. The shrinkage is usually about .006″ in six-pounders, but is as much as .050″ in guns of larger calibre.

The hoop is now heated, very gradually and uniformly, until its bore is a couple of hundredths of an inch larger than the outside of the tube, and slipped over it, to cool and clamp.

After the first row of cylinders is assembled upon the tube, their outer surfaces are turned down to shrinkage and the second row is shrunk on; thus, the gun is really built up.

The wire-wound construction is another step toward the principle of the built-up gun. The use of the continuous wire envelope permits the laying on of thin hoops at increasing tangential tensions and thus more fully arrives at the ideal condition. The wire-wound gun lacks the stiffness of the built-up type and cannot as yet compete with that type in cost of manufacture, but the fact that for guns of the same length and calibre the wire-wound construction requires the less material may justify its use in the navy at least, where the weight carried is a very important factor.

In many respects a gun resembles a gas engine in which the charge is ignited in the cylinder; which, I might add, has suffered the loss of one cylinder-head, and whose piston is not connected to anything in particular. In the gun, however, we have as a source of energy a chemical composition, "smokeless powder," in such proportions that when it is ignited it produces gases at a pressure of about fifteen tons per square inch, which, acting upon the rear end of the projectile, forces it, as a piston, down the bore out of the muzzle. Hence the advantage of a long bore, as it gives a large space through which the gas pressure may act to store energy in the projectile. Indeed late improvement has been strictly along this line, and while the gun in use at present is forty calibers in length, new designs call for a bore of fifty calibers, and the French designer, Canet, has even built a gun of eighty calibers. However, ease of pointing and other practical considerations will preclude extreme length of bore.

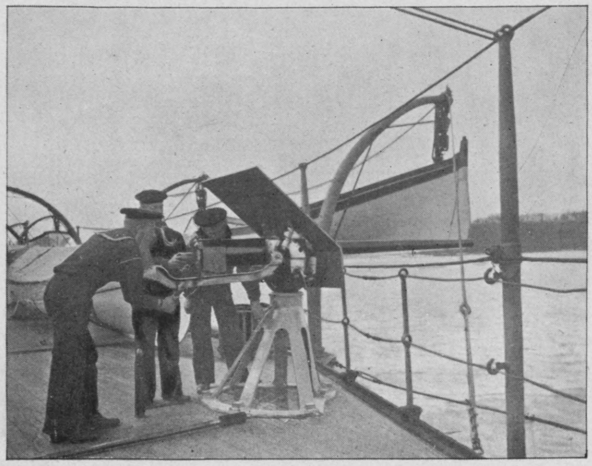
Having, then, as long a bore as is practicable, the other consideration is the motive force or powder—gas pressure. This pressure, for smokeless powder with a density of loading (density of loading is the ratio of weight of powder charge to weight of body of water equal in volume to that of powder chamber) of fifty per cent., is about fifteen tons. In order to utilize the length of bore the pressure must be well sustained towards the muzzle. There are two factors favoring this effect. The first, a large powder chamber; for the pressure curve of the powder gas approximates to an adiabatic, the pressure at the points forward in the bore varying inversely as the ratios of their volumes to the volume of the powder chamber; therefore the larger the original volume, the less will be the drop in pressure.

The other factor for retaining the pressure forward in the bore is a slowly burning powder; that is, a powder that will continue to evolve gas as the projectile moves forward. The improvement in the ballistic properties of the guns of the future lies, probably, as much with the powder manufacturer as with the gun designer.

Smokeless powder of to-day contains as active elements, certain proportions of nitro-glycerine and nitro-cellulose or gun-cotton, together with a detergent body. With the old charcoal powders, in order to obtain higher ballistic effects, the method of using a heavier charge was generally resorted to. Thus we had "service charges" and "battering charges," but with smokeless powder this method cannot be used, and much care must be given to the proportions of the powder chamber.

As an example of the effects of increased density of loading with smokeless powder, I may cite tests at Sandy Hook, in which the addition of one pound to a charge of sixty-six pounds in an eight-inch gun caused the pressure to rise from 34,000 lbs. to 72,000 lbs. per square inch, and on returning to the usual charge the pressure returned to 34,000. One explanation is that when the pressure much exceeds 34,000 lbs. the nitro-glycerine is squeezed out and detonation takes place, causing the excessive increase of pressure recorded.

The advantage of a high muzzle velocity is apparent from a consideration of the projectile energy. The destructive ability of a projectile, other considerations the same, is proportional to its energy. The energy increases as the square of the velocity, so that, speaking broadly, if we double the muzzle velocity we quadruple the shell energy; and a gun with high ballistic properties may equal in destructive qualities a heavier gun, with a lower velocity, and have the advantage of easier manipulation and greater rapidity in firing.



Six pounder Driggs-Shroeder Rapid Fire Gun on the "Columbia."

But there are other advantages besides high power that make the piece efficient in actual warfare. With the use of fleets of torpedo boats there arose the need of a great volume of fire in defence, causing the development of the rapid-fire gun for secondary batteries.

The features of the rapid-fire gun are great rapidity and accuracy of fire, combined with mobility. Rapidity is obtained by the use of fixed ammunition, and a breech mechanism which reduces to a minimum the time required to eject the empty cartridges, cock the firing mechanism, and load.

The modern rapid-fire mount, with its central pivot, carrying on trunnions the cradle in which the gun recoils, allows the gun to be trained through any arc, lateral or vertical. Thus the gunner with his weight against the shoulder bar, which is attached rigidly to the oscillating cradle may aim at will and fire instantly, the gun recoiling in line of fire, and being "returned to battery" by a spring in the hydraulic recoil cylinder.

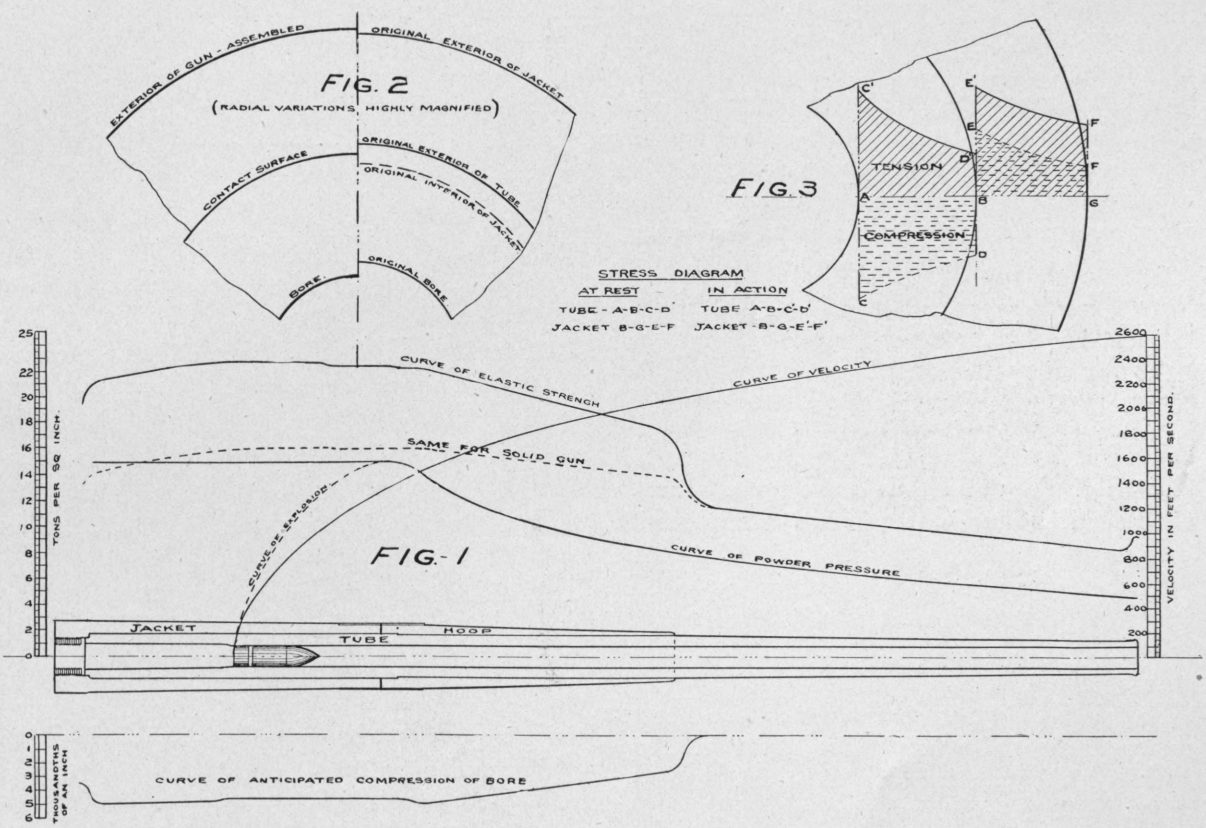
In the different sizes of mounts, the gun is allowed to recoil a distance increasing from four inches, in the case of the 6-pounder, to about four feet in that of the larger guns. The velocity is uniformly retarded by means of fluid pressure against a piston; the piston rod being attached to the stationary part of the mount while the cylinder recoils with the gun.

The fluid passes by the piston through shallow ports cut in the interior surface of the cylinder. These ports are of uniform depth and parabolic shape. The area of the opening thus changes according to the ordinates of a parabola, this following from the conditions of uniform retardation and of constant pressure giving a constant velocity of efflux.

The development of the rifling curve of a gun is a semi-circle parabola, which curve gives theoretically a constant pressure on the sides of the groove. The curve usually starts on a tangent of one turn in 50 calibers and increases in twist to one turn in 25 calibers near the muzzle.

In a high-power three-inch gun, the projectile will leave the muzzle with a velocity of 2,600 ft. per second and revolves at the rate of 416 times per second. This gyrostatic action keeps the point well directed, but causes the projectile to drift gradually to the right with right hand rifling. Why to the right, rather than to the left, has never been satisfactorily explained. The most plausible suggestion is that it is analagous to the peg-top spinning on the floor, whose course on the floor is in the same direction as that in which the top spins. This deviation in the path of the projectile from the vertical plane of fire has to be corrected in the sights.

A graphic representation of some of the foregoing principles is shown in the accompanying diagrams. Fig. 1 shows the longitudinal section



of a 3-inch high-power, rapid-fire gun, designed to give a muzzle velocity of 2,600 feet per second to its 15-pound projectile. Above are plotted curves of elastic strength, powder pressure, and velocity, with their respective scales. The ordinates of the curve of elastic strength represent the internal pressure, in long tons per square inch, which the gun may suffer without producing a greater fibre stress than that of the elastic limit of its material. Below this curve is dotted a similar one for the same gun fabricated from a single forging. The lengths of ordinates between these two curves represent the added strength of the built-up gun due to shrinkage alone, and expose a reason for the failure of certain single forging and special cast guns.

Below the strength diagram is plotted a powder pressure curve, showing the maximum pressure and variation of pressure down the bore. The curve of explosion shows that the powder does not reach its maximum pressure instantly.

The internal pressure in a gun is measured by an instrument known as a crusher gauge. It consists essentially of a plug which is screwed into a hole in the bore of the gun, and which carries a small copper cylinder, between which and the bore is interposed a sort of piston, which receives the pressure of the gases. The amount of permanent set which the cylinder undergoes forms the basis for the calculation of the pressure to which it has been subjected.

The curve of velocity represents the acceleration of the projectile under the force of the powder gases, and is therefore dependent on the pressure curve. The area under the pressure curve, expressed in the proper dimensions and multiplied by the bore area, gives the work done upon the projectile, and is consequently equal to the muzzle energy of the projectile. The muzzle energy is obtained directly by measuring the muzzle velocity.

The instrument for measuring the muzzle and other velocities of projectiles is known as the chronograph. Two wire screens are placed one a few feet in front of the muzzle and the other about six hundred feet further on in line of fire. Each screen is connected in the circuit of an electro-magnet, which holds suspended vertically a long iron bar; the bars being released when the circuits are broken by the shell passing through the screens. Immediately after the bars are released they are struck, in their descent, by a horizontal knife edge which nicks them simultaneously. The difference between the distances of these nicks from the ends of their respective bars gives a basis for the calculation of the time between their release, and hence the time which the projectile took to travel six hundred feet.

The curve of anticipated compression shown below the gun is the best criterion of the condition of finished guns. Over-compression, for instance, is shown by the "star gauge" readings after assembling, indicating a weak tube or irregularities in shrinking.

Fig. 2 illustrates the phenomena attendant upon assembling a gun. On the right are shown sections of the tube and jacket with the shrinkage greatly exaggerated, while on the left is shown the gun assembled with radial compression of bore and extension of exterior greatly magnified.

Fig. 3 shows diagrammatically the tangential fibre stresses which occur during the two states to which the gun system is subject. The horizontally hatched areas represent fibre stresses in a state of rest, while the oblique hatching shows them in action. It will be seen that in the passive state the tube suffers tangential compression, and the jacket tangential tension, whereas in passing to a state of action the tangential compression of the tube is overcome and it suffers tangential tension, the tension in the jacket being at the same time increased until at the surface of contact it is equal to that at the bore. It will also be noticed that in both states the fibres next the bore are subjected to the greatest stress, both of compression and tension, and hence limit the stength of the gun.

ALUMNI NOTES.

F. E. Smith, '96, is traveling for the Smith Sons, Gin and Machine Co.

H. H. Holding, '89, is Vice-President of The Pelton Engineering Co. at Cleveland, O.

E. E. Gilbert, '89, is assistant to the General Sales Manager of the General Electric Co.

E. S. Johonnott, '93, is assistant in the Department of Physics at the University of Chicago.

F. G. Hunt, '96, is Assistant Superintendent of The Riverside Malting and Elevator Co., Cincinnati.

C. M. Ridgely, '96, is employed as draughtsman for the Litchfield Car & Machine Co., at Litchfield, Ill.

G. H. Winters, '94, is Supervisor of the Mexican National Railway Co., with headquarters at Saltillo, Mexico.

E. F. Robinson, '94, is Assistant Roadmaster for the New York Central R. R., with headquarters at Lyons, N.Y.

E. L. Shaneberger, '95, is Assistant Engineer for the Chicago Division of the Big Four, with headquarters at Indianapolis.

The Alumni Association have selected Benjamin McKeen, '85, to deliver the address for the Alumni on commencement day.

C. R. Crockwell, '95, is of the firm of J. D. Crockwell & Son, dealers in wall paper, stationery, toys, china and sterling silver, at Council Bluffs, Iowa.

It will be of interest to the class of '94 to learn of the marriage of S. L. Henrikson and Miss Selma H. Lundvall, March 18.

Bruce Failey, '96, has recently been appointed treasurer of the Terre Haute Brewing Co. He is still secretary of the Blair-Failey Co.

Prof. and Mrs. John B. Peddle have the deepest sympathy of students and alumni in the loss of their child, on Sunday, March 4th.

E. R. Burtis, '95, is with F. H. Walters, fuel contractor for the Colorado and Southern Ry. His present address is 1641 California St., Denver, Colorado.

T. Fletcher, '98, has been sick the greater part of the time since he graduated, but is at present very much improved. His address is Little Rock, Arkansas.

W. E. Ford, '98, is with the Choctaw & Memphis Construction Co. At present he is engaged in construction work for the Little Rock & Memphis R. R.

Arthur Hood, '93, now a patent attorney in Indianapolis, visited the Institute the first of the month. Arthur V. Tuller, '95, of Carrier Mills Inn, also spent several days in Terre Haute.

C. Pirtle, '98, and F. W. Schneider, also of '98, are in the testing department of the General Electric Co., at Schenectady. Their work consists in testing transformers and rotary convertors.

George R. Wells, '96, with the Wagner Electric Company, has been promoted to the position of traveling erecting engineer for that company. He will supervise the installation of the large transformers built for the Niagara Power Company.

H. S. Heichert, '97, who accepted the position of assistant in the Mechanical Engineering Department of the Worcester Tech, states that his duties consist in directing the experimental work in the laboratory and in occasionally assisting or conducting recitations.

F. A. Whitten and C. E. Theobald, both of '98, are room-mates in New York City. Theobald, who is with the New York Telephone Co., states that he is becoming "well acquainted with all classes of people, from owners, agents and lessees of buildings down to the engineers, firemen and servants."

"Telephony and a Modern Telephone Exchange."

MR. F. E. BAUSCH.

Lecture delivered at Rose Polytechnic Institute, March 16, 1899.

TWENTY-THREE years ago, at the Centennial Exhibition at Philadelphia, an ingenious instrument, capable of reproducing articulate speech, attracted universal interest. This instrument was destined to play a marvelous role in the progress of electrical science. To-day it surpasses the most sanguine expectation then predicted for its future application. Since the inception of the telephone to the present day of the mammoth switchboard, where time and distance are annihilated and people are brought together as though face to face, where tens of thousands of wants are satisfied daily, the evolution of the telephone industry and its stupendous growth are indeed significant. It is estimated that there are one and one-half million phones in the world in daily service, half of which are alone used in the United States.

The brief and brilliant history of telephony is not unlike that of other great industries founded on great inventions. It may be readily divided into three great epochs. First, the period when the demand for its existence was created and when the invention must show signs of practical application; the middle epoch, covering the time of actual experience and its assured reality, finally the period when refinements of the art are introduced, such as the range extended, speed increased and a standard attained, such as is set by the public of today. To illustrate these three divisions of progress, we may refer to the stage of overhead, grounded circuits, subject to induction and interference; of experimental switchboard apparatus, developed hurriedly to meet the demand for service and of appliances and apparatus more or less experimental throughout. The systems worked and telephone exchange service was given, but both the givers and receivers of such service constantly demanded something better. The next stage is marked by the fulfillment of the urgent requirements of the business. It meant metallic circuits and underground wires, switchboards were improved and a host of accessories added, which materially aided the smooth working and reliability of service. The last stage, in which we now find ourselves, is that of adding refinements to the solid basis of efficient working already established. The range of telephony is being greatly extended, the reliability of service is rendered more complete, and the speed and accuracy of operation are increased by the introduction of improved methods of signalling and operating, in which a fair proportion of the actual working is automatic.

A telephone plant may be readily divided into three constituent elements—first, the subscribers' stations; second, the central office, containing the switching apparatus, and third, the line plant connecting the two.

The subscribers' station consists of an apparatus to receive and send signals, of a transmitter to talk through and a receiver to listen through, the latter of a type little modified from the original Bell telephone, the invention of which founded the art of telephony. A magnet telephone is the simplest and most delicate instrument known to science. The parts that compose it are so few and the combination so simple, that any boy can place them together and make a talking telephone. They have been in the hands of electricians since the days of Faraday and Henry, but it required inventive genious of the highest order to discover that with an electro-magnet and an armature in the shape of a thin iron disk, an instrument could be made, capable of transforming the delicate and complicated sound waves produced by the human voice into electrical waves of precisely the same character, which would be retransformed into sound waves at the distant end of the line.

The Bell telephone used as a transmitter is a miniature alternating current dynamo, and as a receiver, an alternating current motor. Its delicacy as a receiver of currents is unapproached—its power of responding to an electric current being so great that the amount of current required to light an ordinary incandescent lamp would, if subdivided, make an audible sound in every telephone receiver in the world—yet its power as a transmitter is necessarily limited by the energy of the human voice. With an ordinary Bell telephone, the best frequency for appreciating very feeble currents has been found to be 640 p. p. s. This corresponds approximately to the frequency of the musical note E in the treble cleff. At this frequency an alternating current strength of $\frac{45}{1000000000}$ ampere produced distinctly audible sound. Calling the millionth of an ampere a micro-ampere, and the billioneth a bicro-ampere, this current would be 45 bicro-amperes. Accepting this figure, which is a rather conservative estimate, the amount of energy which would be required to be expended to maintain this current strength through the electrical resistance of a telephone, which is about 75 ohms, is so exceedingly small, that the work done in lifting a thirteen ounce telephone through a vertical distance of one foot would suffice to keep an audible sound in a telephone for 240,000 years.

The early form of Bell receiver was that of a horseshoe magnet attached to a base board, the diaphragm placed upright opposite the poles, and a mouth piece mounted in front of the diaphragm. It was found that a large air chamber between the mouth piece and the diaphragm rendered articulation indistinct, and the first improvement was in the shape of a mouth piece, reducing the air chamber between the mouth piece and the diaphragm to very narrow limits. The best results were obtained by giving the mouth piece a very narrow orifice, in this way providing a thin layer of air between the diaphragm and the cap, with a small opening in the center of the cap. This arrangement gave the sonorous vibrations their maximum effect on the diaphragm, a most important consideration. The horse shoe magnet was soon discarded and a bar magnet substituted.

This was inclosed in a case which protected magnet and coil and at the same time served as a handle by which to hold the instrument. Thus the hand phone or receiver used throughout the United States was evolved. With but one exception, the modifications that have been made in it during the last sixteen years have been merely in the minor mechanical details and in the improvement of the qualities of materials used. The double pole magnets are used for long distance work. For ordinary purposes the single pole receiver gives excellent results. The magnet of this pole receiver is made of the best quality of steel. It is 4½ inches long and is built up of four strips separately magnetized. It should hold up a weight of 16 ounces. At one end is fitted a soft iron pole piece to hold the hard wood spool on which the coil of insulated copper wire is wound, and at the other a piece of iron is threaded for making final adjustments by means of a screw. The wire is generally of 38 B. & S. G. silk covered, and wound to a resistance of 75 ohms. The diaphragm is .01 of an inch thick, and about 2¼ inches in diameter. When the diaphragm is clamped down by screwing on the mouth piece, its lower surface is about $\frac{1}{32}$ inch above the pole of the magnet. The containing case is made of hard rubber.

However energetic, the human voice may sound at times the amount of electric energy it is capabie of producing in a magnet telephone is very small, and consequently the range of talking is comparatively limited. To give to the telephone the range it was destined to have, a battery transmitter was necessary. Its effectiveness depended upon two electrical phenomena, the variation in the resistance of an electric circuit and the phenomenon of induction which permits the transformation of a current of low voltage into one of a higher voltage, by the inductive transfer of a current between two circuits wound side by side around a common center. After the introduction of the Edison carbon telephone and the Hughes microphone, the Bell telephone was relegated to the place of the receiving instrument on a telephone line, and microphonic telephones, because of their much greater power, were used for transmission of speech. Now all magnet telephones are referred to as receivers, and carbon telephones as transmitters.

Carbon transmitters may be divided into three classes: Those that employ a single contact for varying the resistance of the primary circuit, such as the Blake; those that employ several con tacts, of which there is a large number, all of them modifications of the original Hughes microphone; and those which are based on granular carbon, known as the Hunning type, after the originator of this idea. In this country only three forms of carbon transmitters are in general use—the Blake, the Long Distance and the Solid Back. The last two are modifications of the Hunning transmitter employing carbon granules. Prior to the adoption of the granular carbon transmitter by the leading telephone administrations, the Blake transmitter, employing a carbon button, was used almost universally in the United States, Great Britain and Canada. At present the Solid Back transmitter is being installed in modern telephone plants. It is admirably adapted for long distance as well as local service. The solid back transmitter, so familiar to the public of St. Louis, since the installation of the new Bell exchange, is inclosed in a metallic case and carried by a swivel arm. Behind the rubber mouth piece is the diaphragm, damped by the usual dampening spring. A pin is clamped by a pair of small nuts to the center of the diaphragm and carries a metallic button rigidly connected with the carbon disc or electrode. A similar carbon disc let into a metallic socket forms the back of a small circular recess partly filled with granulated carbon. The walls of the recess are lined with varnished paper. The front cover of the recess consists of a thin sheet of mica, through which the back of the front electrode passes. The back electrode holder is securely clamped in a metallic bridge piece supported by the bell shape frame. The vibrations of the diaphragm are communicated to the front carbon electrode, through the pin, the mica cover being sufficiently thin and elastic to freely permit this vibration. As the carbon disc is sensibly smaller in diameter than the recess, it allows free movement of the granulated carbon particles, so that the instrument is less likely to give trouble from packing than other forms of carbon transmitters.

In the course of Edison's experiments with carbon transmitters, he found that by making his variable carbon resistance part of a primary circuit, including a battery and a coil of thick wire, and causing this coil to induce currents in a secondary coil of thin wire, the ends of which were connected to the line, he obtained far better effects than with the battery and variable resistance in the main current. This was quite an important discovery, and the induction coil has since formed an indispensable part of almost all battery telephone transmitters. An entirely local circuit is made up of the carbon resistance, the thick or primary wire of the induction coil and the battery. The ends of the fine or secondary wire of the induction coil are connected to the line and therefore to the receiver at the distant station. The induction coil is simply a small step-up transformer, the principle of transmission being precisely the same as that used in lighting and power with alternating currents.

The efficiency of a telephone transmitter, generally speaking, depends on the range of variation of current strength capable of producing in the primary circuit. It would seem at first thought that the efficiency of any transmitter might be improved indefinitely by simply increasing the battery power. But this is not true. The variable resistance of every transmitter is a delicate piece of apparatus. A certain amount of heat is always developed at the points of the carbon contacts and minute arcs are formed of the carbon particles where the current passes between the contact. Heat up the carbon contacts too much by using too strong a current and you impair rather than improve the efficiency of the transmitter, in fact, a point would be reached where the instrument would refuse to talk. A common expression of "wires kept hot with messages" is truly applicable in telephony as far as the transmitters are concerned, for they may be made red hot by excessive battery power.

The sensitiveness of the telephone requires very peculiar conditions in the telephone line. From an electrical point of view, the telephone line is a most delicate construction, while mechanically it must be substantial to withstand all ordinary strains and stresses and must comply with the various exigencies of situations overhead, house-top, pole lines, underground and submarine. The chief point about a telephone line is that it must be what telephone men call a "silent line," i. e., it should be silent to all but the currents intended for it. In place of perfecting a system of multiplex telephony, such as is employed in telegraphy, the aim of telephone men has been to so design a line that it would carry a single message at any one time, uninterrupted by external influences.

With the introduction of telephone exchanges and before any precedent as to most efficient material was established, telegraph practice was followed rather closely and quite naturally iron-wire ground circuits were used. Ample experience, subsequently, has shown the unfitness of iron wire in telephony due to its property of electro-magnetic retardation. Copper or bronze and the adoption of a complete metallic circuit was soon substituted on account of the telephonic current and the extreme sensitiveness of the telephone receiver.

Reproduction of telephonic speech at the receiver depends on the accurate reproduction without change or distortion of every minute wave or variation initially produced in the transmitter. The variations are as many as a thousand per second. Therefore, any interference, such as electro-magnetic inertia or retardation, which distorts and retards the original, destroy all character of telephone current. Iron possesses this quality to a pronounced degree, hence its unsuitability for line work, except for short distances. Copper has scarcely any electro-magnetic inertia, while its specific resistance is much lower than that of iron. Copper speedily displaced iron for telephone conductors. After it was decided what material was best adapted for line work, the next and most vital consideration was to produce lines which should talk well and far, and, if possible, eliminate the undesirable induction.

The three characteristic properties of electric conductors are resistance, capacity, and insulation. Resistance tends to diminish the strength of the current at the receiving end by absorbing energy in the form of heat. Capacity tends to diminish the strength of current by absorbing a portion of the charge at every change in the strength or direction of the current. The insulation of the conductor depends on the resistance of the non-conducting material interposed between the conductor and the earth. This resistance should always be high, so as to confine the current to its proper path, the conductor. Should the insulation resistance diminish to a certain point along the line, part of the current would flow to earth and the strength of the received current at the distant end would be very much impaired. A complete loss of insulation at any point means, of course, the electrical break down of the line. Such a break down is caused, for example, by a fault in the insulating cover of a submarine conductor, admitting water to contact with the wire, or a direct contact of an overhead wire with an iron pole or cross arm. Resistance depends on the material of the conductor and its cross-section. The larger the cross-section, the lower its resistance. Naturally, since the transmitter has reached a state of high efficiency, and the receiver is so sensitive, effective results are produced over lines of much higher resistance than are found in any other transmission circuit. Capacity depends on the surface of the conductor and on its proximity to the earth or other conductors connected to earth. When the conductor is separated from the earth only by an insulating covering, as in a submarine or underground cable, the capacity also depends on the nature of that insulating covering. Just as conductors differ in specific resistance, copper having a much lower specific resistance than iron, so do insulators differ in specific capacity. Dry air has the lowest, while for coverings of cable conductors, dry paper or cotton have a much lower capacity than gutta percha or India rubber. The effect of capacity is generally regarded in this way. If you send a current of electricity into a conductor you must charge that conductor before any effect results at the further end. The amount of charge it will receive depends upon the capacity of the conductor. When dealing with continuous or direct current, this phenomenom practically does not affect the current at all, however high the capacity of the conductor for absorbing a charge may be; as the moment the current is applied, the conductor will be charged and remain so until the circuit is broken. In dealing with intermittent or alternating currents, the effects of capacity are extremely pernicious, because the conductor is constantly being charged and discharged, possibly thousands of times per second. The effects of capacity are to absorb and slow up these rapid charges, distorting their form with the result that you produce electric waves at the receiving end of different shape from those that are sent at the transmission end.

Any property of the conductor which tends to change the shape of the waves, to absorb them or distort them in general, is a hindrance to telephonic transmission. Capacity then is the greatest annoyance in telephone work. The most conspicuous example of an excess of capacity is an ocean cable. The capacity of an Atlantic cable so completely absorbs telephonic currents that you might just as well stand on the Atlantic shore and shout to your friend in London, as to try to convince him by telephone. A wire strung high in the air has the lowest capacity, while a conductor insulated with gutta percha and submerged in the sea has the highest. The submarine conductor has a retarding effect on telephonic current, about thirty times greater than the overhead wire, so that the longest North Atlantic cable, which is rather more than twice the length of the telephone line between New York and Chicago, is equivalent to an overhead line more than 60,000 miles long. At present there is no demand for a line of that length. Anyone who has talked over a modest 1,200 or 1,500 mile line, where the limit of transmission is very nearly reached, can appreciate that connections over a line offering thirty times the retardation, is not at present within the range of commercial telephony. Underground service demanded a type of cable different from any used before. It was plain that gutta percha or rubber insulation would not do for telephone cables on account of the high capacity of such materials. For this reason, it was necessary to resort to fibrous texture, such as cotton, hemp and paper. By covering the cotton with paraffine or some heavy oil, a cable was obtained which gave a high insulation and a relatively low capacity, only about one-half to two-thirds that of gutta percha. Owing to the readiness with which fibrous materials absorb moisture the development of this type of cable was proceeded with slowly, to gain the necessary experience. After all the insulation of the cable depends on the continuity of the lead sheath forming its outer covering. As soon as it was found that the lead sheath could be trusted and thus prevent moisture from reaching the insulation, which might readily absorb a sufficient amount to render the entire cable useless, improvements in the manufacture of telephone cable rapidly progressed and the modern type of dry core air space cable was developed. In this type of cable the conductors are covered with a loose wrapping paper, which does not adhere closely to the wire, leaving spaces occupied only by air. Dry paper alone is preferable to cotton impregnated with compound or paraffine and the introduction of the air space still further reduces the capacity. As a result, we have cables today with conductors having from one-third to one-half the capacity of cables made eight or nine years ago. A mile of underground conductor of the first type of telephone cable was equivalent in its retarding effect to from eighteen to twenty miles of overhead wire, while the underground conductor of today is equivalent to only about seven to eight miles of overhead wire, which is a very considerable advance. In telephone cables the wires are always twisted in pairs, the two conductors of a circuit making a revolution around each other about four times in each foot. This suggests the consideration of the requisites of a silent telephone circuit, one which shall be silent to foreign currents. To attain this condition, it is necessary that the two sides of a circuit shall balance accurately in their electrical properties and their exposure to induction from other current bearing wires. If the circuit is properly balanced the foreign currents which appear on each side of it by induction from neighboring wires will oppose each other and their effect on the receivers be neutralized. If the circuit is unbalanced by more resistance or more capacity on one side of the circuit or if one side of the circuit is more exposed to induction than the other, the induced currents on one side will overpower those of the other and there will be a disturbance in the receivers. This disturbance may consist simply of noises or of telephonic currents producing perfectly clear talking from one circuit to another, an effect commonly known as cross-talk.

In the early days of telephony it was believed that metallic circuit in place of a single wire grounded circuit was a complete cure for induction and the first long distance lines were erected without precautions in the way of balancing the circuits, or of exposing each side equally to its neighbors. The result was that a single conversation set all the circuits on one line of poles talking together, so perfect was the induction or cross-talk between straight metallic circuits. Now that ample experience has been gained in this respect, an induction proof circuit is constructed by stringing the wires along the same route at an equal average distance from each other, and at stated intervals transposing by crossing the wires, giving the first wire the position of the second, the second the position of the first, and so on. The effect is that the relative exposure of each wire to induction from the rest is the same along the whole route. In the city overhead line construction poles of 40, 45 and 50 foot lengths are generally used, set five to six feet in the ground and spaced about 125 feet apart. These figures are modified according to conditions met with in the line. The cross-arms are ten feet long, carrying ten pin insulators.

The line system of the Long Distance Co. is based on rigorous metallic circuit working and high grade construction throughout. Thirty-five foot poles are used, set six feet deep, and on the average 130 feet apart. The cross-arms are 3¼ x 4¼ and carry ten pin insulators. The copper outlay in the construction of such lines is enormous. The New York-Chicago line of 950 miles carries over 400 tons of copper wire. The total surface exposed is 433,000 square feet.

Reference to overhead wires, which is now a matter of interesting history in the business district of St. Louis, suggests the underground telephone service recently installed. I can in no better manner illustrate the construction, equipment and operation of a modern telephone exchange than by giving you the facts of a telephone plant which has come under my immediate observation, while connected with the Bell Telephone Co. of Missouri.

Mr. Bausch then stated the reasons that made a change necessary in the existing system of telephony which resulted in the construction of the conduit system of the Bell Telephone Company, of Missouri. The conduit system of distribution of the large underground mains, the division of the circuits into branches, the location of cable heads for local distribution, etc., were illustrated by a number of excellent views.

The collosal switch board, from the Western Electric Company, of Chicago, of the common battery, multiple branch terminal type, was illustrated and a detailed description followed, which we regret can not be reproduced for lack of space.

It may be possible to realize the enormous and complicated system of wiring in a modern exchange when it is stated that the outlay of wire required in the installation of this exchange was about 5,600,000 feet of wire in the straight away cables, and 9,218,000 feet of wire in the relays and other coils. The number of soldered connections between the termination of the cables on the main distributing board and the operators' switch board is estimated to be at least one half million.

Contrary to the Law system, where the local batteries are required at the subscribers' instruments, thus necessitating a great deal of inspection and renewal, the most modern and simplified form of battery transmission as illustrated in this board, concentrates the electrical energy at a central point for distribution. In the battery room, which is the heart and lungs of the telephone exchange, large sets of storage batteries are installed. Eight large cells of style 31G chloride accumulator feed the miniature 8-volt cord signal lamps. While one set of four cells is being discharged the other set of four is being charged from the motor generators. The normal useful capacity of these cells is 3,000 ampere hours. Ten cells of 11G type are used for talking current over the lines. They are charged at the rate of 50 amperes and 24 volts. The discharge is at 20 volts, while the current necessarily varies, ranging from 10 to 50 amperes. In addition to these, there is a set of six cells of style 11F to supply current for the transmitters and line signals.

In the power room adjoining are the motor generators, including the ringing and busy signal machines manufactured by the Western Electric Co. Current for ringing and signaling is furnished from the same machine.

During the day, current for the motor generators, which charge the batteries, is furnished by the local plant in the basement of the building. This consists of a 10 h. p. horizontal Ball engine, direct connected to a direct current machine, capable of an output of 50 amperes at 220 volts. At night, or in cases of emergency, current is tapped from the mains of the Missouri Edison Electric Co., or received over a feeder directly connected with the local branch exchange in South St. Louis. The motor generators receive the current at a pressure of 220 volts. This is transformed by a secondary winding to a voltage adapted to the capacity of the storage batteries which they charge. Either of the two large machines charge the ten cells used for talking current at 24 volts and 60 amperes. The third machine used for the 8 volt battery is capable of delivering 150 amperes at 12 volts. These batteries furnish current for the cord signal lamps. A fourth machine charges, at different times, two sets of batteries, a 2 volt and a 4 volt, respectively, the former used for the operators' transmitters, the latter for the line signal lamps. The machine can deliver at its secondary 60 amperes at 6 volts. The ringing and busy back machines, previously mentioned, complete the list of generators. The units are so selected that in case of injury to any one machine resulting from a burnt out armature or otherwise, the operation of the exchange is not in the least affected.

It is needless to observe that with metallic service installed it is possible for a subscriber, without leaving his office, to communicate with a person in any city in the United States where long distance service has been established. Thus it is a common occurrence to send or receive messages to and from Chicago, New York or Boston, in fact the people from the state of Maine may converse with their friends in Nebraska with nearly the same facility and clearness as experienced over a local connection.

THE STUDENT COUNCIL.

On February 27th, the Council drew up the following resolution as the result of their investigation of the financial condition of the various organizations, and presented the plan to the Faculty:

To the Student Body of the Rose Polytechnic Institute:

The Council, after due consideration of the present state of interest in the Organization of the Institute, makes the following recommendations, to be acted upon by the student body in General Assembly on Thursday, March 2nd, at 5 p. m

1st. The Council recommends that an assessment of $10.00 be made upon each student, per year, to be known as the "Student Fund" This is to be so announced in the catalogue by the Faculty. The payment of this fund is to be made at the time of the collection of the tuition and incidental fees; $4.00 to be paid the first term, $3.00 to be paid the second term, $3.00 to be paid the third term.

2nd. This fund is to be divided among the Organizations as follows:

To the Athletic Association	40	%
To the Technic	15	"
To the Y. M. C. A	12	"
To the Scientific Society	3	"
To the Telegraph Association	2½	"
To the Camera Club	2½	"
Total	75	%

3rd. The surplus of 25% is to be known as the "General Fund" and is to be used at the descretion of the Council, in order to promote the greatest interest and activity in all of the Organizations.

4th. "The Student's Fund" shall pay all the obligations of the student to the Athletic Association, Gymnasium, Technic, Scientific Society, and shall also entitle the student to associate membership in the Y. M. C. A., Camera Club, and Telegraph Association.

5th. This shall go into effect at the beginning of next term and the assessment of $3 00 shall be made and collected with the tuition.

HARRY C. SCHWABLE, President.

JOHN T. DICKERSON, Secretary.

JOHN F. SCHWED,
S. J. KIDDER,
T. D. WITHERSPOON, } Committee.

ROSE POLYTECHNIC INSTITUTE, Feb. 27th, 1899.

The Faculty having approved the method of creating a "Student Fund," to which every student should subscribe, agreed to undertake the collection and enforcement of the payment at the same time as tuition was collected, providing the majority should agree to the plan.

The resolution was then posted on the bulletin board, and after due notice was presented to the student body for adoption. A heated discussion followed as to the divisions of the funds which had been recommended by the Council. After several amendments had been made and lost, the resolution was finally adopted with the following amendment:

That of this fund, 50% be devoted to the maintenance of the Athletic Association and Gymnasium; 15% to be paid to The Rose Technic; 5% to be for the support of the Scientific Society; making 70% in all.

That the surplus of 30% be known as "The General Fund," and be used at the discretion of the student body to promote the greatest interest and activity in all the organizations.

The resolution, with the above amendment, was finally adopted by a vote of 59 to 17.

The Council at once saw the impossibility and impractibility of carrying out the resolution as adopted, as it required a ⅔ vote of the student body to make any disbursement of money from the "General Fund."

The matter was reconsidered and the following resolution was adopted in place of the first, and posted on the bulletin board:

In view of the inability of the present student organizations to collect sufficient dues to promote their several objects, and because the financial affairs form such a prominent part in the maintenance of college organizations, we, the Student Body of the Rose Polytechnic Institute,

Resolve, That an assessment of $10.00 per year be made upon each student. The money collected to be known as the "Student Fund." The payment of this fund to be made at the time of the collection of the tuition, $4.00 to be paid the first term, $3.00 the second term and $3.00 the third term; this to be announced by the Faculty in the catalogue. The collection and enforcement of the payment to be undertaken by the Institute.

That of this fund 50% be devoted to the maintenance of the Athletic Association and Gymnasium; 15% to be paid to The Rose Technic; 5% to be for the support of the Scientific Society; making 70% in all.

That the surplus of 30% be known as "The General Fund" and be used at the discretion of the Council to promote the greatest interest and activity in all the organizations.

That the Council place this money to the credit of the various organizations, to be paid to them as their expenses demand until their quota has been reached.

That if, at the end of the school year, it is found that the expenses of any organization have not necessitated the expenditure of the amount placed to their credit, the surplus is to be turned into "the general fund."

That the payment of the assessment shall defray all obligation of the student to the Athletic Association and Gymnasium, The Rose Technic and the Scientific Society.

That the above provisions go into effect at the beginning of the Spring Term of 1899.

HARRY C SCHWABLE,
President of the Student Council.

JOHN T. DICKERSON,
Secretary of the Student Council.

T. D. WITHERSPOON, }
JOHN F. SCHWED, } Committee.
HARRY C. SCHWABLE, }

ROSE POLYTECHNIC INSTITUTE, March 6th, 1899.

According to Sec. 3, Art. II of the Constitution, the above resolution will be considered approved by the student body if no objection is filed in writing with any member of the Council in three school days after the publication of this recommendation.

Attention is called to Sec 3, Art II, which says: "If, at any time, the Student Body is dissatisfied with any act of the Student Council, a two-thirds vote of said Student Body shall veto said act."

Objection having been taken and presented in writing to the Council, the matter was reconsidered. The point objected to lay in Article II, Section 3 of the Constitution, which reads:

If, at any time, the student body is dissatisfied with any act of this Council, a two-thirds (⅔) vote of said student body shall veto said act.

All acts of the Council shall be made public either by publishing on the official bulletin board or by reading in general assembly. No exception having been taken to any act within three school days after its publication, the same shall be considered approved.

The objection was raised upon the point that it only required a vote of ⅓ to carry a resolution, while a ⅔ vote was necessary to veto said act. As the Council has not the executive power of the student body, but only the legislative power, this clause of the Constitution was amended to read:

All acts of the Council shall be made public, either by publication on the official bulletin board or by reading in general assembly. No exception having been taken to any act within three school days after the publication, the same shall be considered approved. If a written exception, signed by fifteen students, is taken to any act of the Council, it shall require a two-thirds vote of the student body to ratify the action of the Council.

This amendment was presented to the student body and passed by a two-thirds vote. All objection having been removed by this change in the Constitution, the Resolution No. 2 was adopted and became a law.

With this additional duty upon the Council, a treasurer was required to take charge of the finances of the student body, and the following amendments to the Constitution were made:

AMENDMENTS.

Article I., Section 2, amended to read:

The Council shall choose its own officers. They shall be a President, a Vice President, a Secretary, a Treasurer and a Clerk These officers shall be elected at the first meeting of the year, to hold office for a term of one year.

In case of a Councilor losing his seat, the vacancy in office shall be filled by an election.

Article I., Section IV., amended to contain:

The Treasurer shall receive all money for the Student Fund, and shall be held responsible for the records pertaining to the same. He shall perform all other duties belonging to this office as prescribed by the Council.

The Council also made the following recommendation, which was not voted on; that Article I., Section I., be amended to read:

"All legislative powers," in place of "all executive powers," as the Council does not assume executive power, but only legislative.

The constitution of the Athletic Association was brought up for discussion at the last meeting of the Council, and found to be in a bad condition. The Council made a number of recommendations to the Committee on Revision which have not yet reported upon the necessary changes that have been made.

Two suggestions were presented to the student body by the Council for consideration as possible additions to the Constitution of the A. A., under the present new conditions of finances:

1st. That students shall be admitted free to all athletic games.

2d. That the Treasurer of the Athletic Association shall not be allowed to draw upon their quota of the Student Fund so long as the treasury has sufficient funds, arising from gate receipts, etc.

These suggestions were discussed and finally laid upon the table to be voted upon later.

VIBRATION TESTER.

In the design of high speed machinery it is of great importance that all the revolving parts be accurately balanced. This is particularly the case for certain critical speeds. These speeds depend, in the case of any one shaft, on the amount of the deflection of the shaft produced by the gravitational load carried by it. This deflection can be calculated from the dimensions of the shaft, the load and the elastic constant of the material. Hence the critical speed or speeds can be foretold.

In order to illustrate the importance of this subject an apparatus has been constructed in the shops of the Institute. This consists of an accurately turned shaft carrying a heavy disc provided with balancing screws. The shaft runs in ball bearing so designed as to give freedom for transverse vibration. It is driven through a flexible joint by means of a friction gearing combined with a set of cone pulleys, which enables the speed to be gradually varied through a wide range.

This apparatus shows that it is almost impossible to produce a sufficiently perfect balance to prevent violent vibration when the period of rotation of the shaft is the same as that of its free elastic transverse vibration. Half this speed is also somewhat critical, although much less so. In the actual experimental apparatus the shaft vibrates somewhat when the speed of rotation is between 400 and 450 revolutions per minute, and violently at speeds in the neighborhood of 850 revolutions per minute. Higher speeds, even above 1700 revolutions per minute, show perfectly steady running.

TEST OF TERRE HAUTE HOUSE STEAM PLANT.

During the past term Prof. Wagner has been testing the machinery of the Terre Haute Hause Company's plant, and the work is about completed. In the tests of the engines, pumps and refrigerating machine, he was assisted by Smyth, Crebs and Butler, while in the boiler test the entire Senior class was mustered into service. The latter test lasted twenty-four hours. Groups of four men working six hours at a trick with Prof. Wagner and Mr. Grosvenor in charge. The boys learned to shovel and weigh coal and ashes, weigh up leaks in steam pipes and several other things not mentioned in the curriculum. They enjoyed it, however, and apparently worked hard, for the excellent meals that Mr. Baur sent over to the boiler house (always just in the nick of time) disappeared as if by magic.

LECTURE COURSE.

The course of lectures on general topics began on Thursday, 16th. Mr. F. E. Bausch of St. Louis, for a long time chief engineer for the St. Louis Telephone Exchange, but now of the Missouri Edison Electric Company, delivered the first lecture on "Telephony and a Modern Telephone Exchange."

Mr. Arnold Layman, Treasurer of the Wagner Electric Co., St. Louis, will deliver a lecture during the first week in April.

Mr. Walter B. Snow of the Sturtevant Blower Co., Boston, Mass., will lecture on "Forced Draught" on April 20th. A number of other lectures will follow, but the dates have not been settled and will be announced later.

SHOP NOTES.

Benjamin Grosvenor, who for many years has been Engineer and Instructor in Boiler Management, has given up his position at the Shops in order to accept the position of erecting engineer with the Connersville Blower Co. His first duty will call him to Texas, where he will be engaged in installing a large plant. During his long stay at the Institute he has made many friends, both by his competent instruction and friendly interest in the students. The alumni and students are therefore unanimous in wishing him success in his new position. His family will remain in Terre Haute for the present.

NOTES.

A party composed of eight students, most of them Sophomore Civils, spent Washington's birthday in visiting the coal mines and Powder

Works at Fontanet, Ind. Under the guidance of Mr. Talley, the son of the president of the company, they went through the Union Mine, one of the largest in this part of Indiana. One of the amusing incidents of the trip was the encounter of McKibben with one of the hydraulic picks. What seemed so easy when the miner did it became a different matter when he himself tried it.

The Powder Works, where large amounts of blasting powder are being made for use in the mines round about, were of great interest to the men. When they reached town again, in spite of the grimy condition of faces and clothes, all agreed that the trip had been a very profitable one.

The appointment of Professor A. A. Faurot as a member of the Library Commission in accordance with the provisions of the library law recently passed by the General Assembly, would be most fitting. Mr. Faurot was especially active in passing the bill. He is a thorough librarian, and has made library matters a close study. The proper execution of the provisions of the bill will be of great benefit educationally, and it is to be hoped that the commission will be composed of men chosen purely because of their qualifications and willingness to give their best efforts to the work. That Mr. Faurot is such an one cannot be doubted.—*Terre Haute Gazette.*

BASE BALL.

The following is a list of the important games that have been scheduled for the coming season :

Monday, April 24—DePauw at Greencastle.
Saturday, May 6—State Normal. (Normal Supervision.)
Saturday, May 13—DePauw at Terre Haute.
Saturday, May 20—Field Day. No game.
Saturday, May 27—State Normal. (Rose supervision.)
Tuesday, May 30—Wabash at Terre Haute.
Saturday, June 3—Wabash at Crawfordsville.

Practice games will be arranged early in April with the Normal, High School and Van. Shop teams.

DIFFERENTIALS

The catalogue for '99 is already in the hands of the printer and will soon be ready for distribution.

Mr. Wires was sick a few days last month and the Freshmen had a few hours' vacation from the wood-shop.

Hammel, '01, was observed, while oiling a bearing, to carefully oil the center hole in the end of the shaft.

The Freshmen are reading Zschokke's "Der Zerbrochene Krug," having finished Niebuhr's "Heroen Geschichten."

Mr. Lawrence, principal of the Sixteenth District School, brought several classes to the Institute to visit the museum.

Interesting experiments are in progress in the shops on ball thrust bearings, under the direction of Dr. Gray and Professor Peddle.

Dr. Gray gives two hours of practice in the solution of mechanical problems to the Senior class each Friday. The exercise is most excellent.

Pfleging, '00, played forward on the Y. M. C. A. basket ball team that met defeat from the Indianapolis Y. M. C. A. team on Feb. 3d. Score, 30 to 12.

Wilbanks, ex-'02, who withdrew because of ill health, was ordered south by his physician. He is now in Texas, and will probably enter the University of Texas.

Designs are being made for an air compressor for use in the shops, as well as to illustrate the method of utilizing compressed air in the manufacturing establishments.

A number of the Rose Tech men received invitations to attend the dance given by the Normal Athletic Association at Duenweg's Hall, Friday evening, March 10, 1899.

Professor R. L. McCormick read an exceedingly interesting paper before the Terre Haute Science Club, on Feb. 20th, upon "The Forms of Soap Bubbles and Soap Films."

Professor Hathaway: "Imagine this pendulum to be vibrating in a liquid that will uniformly retard its motion." Insley, '00: "Can't you assume the liquid to be syrup, Professor, so as to interest Larson?"

A number of specimens of chains used in the construction of conveyors donated by the Jeffrey Manufacturing Company, of Columbus, Ohio, have just been received. They will be of great use in the machine design department.

Despite the present difficulty experienced in getting into the gymnasium, the handball enthusiasts continue to play. The court is especially sought after on Saturday afternoons, and has not been vacant a single one the entire term.

Weekly journal reviews have become regular features of two of the courses, Chemical and Civil. Their value lies not only in the information they give, but in the broadening of the mind which is the direct consequence of the diversity of the subjects treated.

The Seniors submitted thesis subjects February 25th. The combinations of pairing and tripling will result in about ten papers from the class. In most cases more than one subject was submitted. The April TECHNIC will be able to report the selections. The range includes some new subjects and also some old ones, in which the students will profit by past investigations and attempt to go further with the research.

The Junior class, in Machine Design, has commenced a journal review of current topics, bearing specially upon machine construction and methods, strength of materials, etc. Although a new feature, still it has proved of great value, and will no doubt be continued throughout the course.

Those who have attended both a performance of "The Highwayman" and one of Professor Hathaway's Quaternion lectures, (if such things will stay so close without explosion), can perhaps imagine the Professor saying, "How does the master mind solve *this* problem? That's *my* secret."

A New York newspaper correspondent, in referring to an accident which delayed the steamship St. Paul, in arriving at her port, said that the assistant engineer discovered steam *oozing* from a crack, eight inches long and a sixteenth of an inch wide, in one of the main steam pipes. The St. Paul carries *200 lbs.* boiler pressure.

American Machinist prints the translation of an account of the Home Life Insurance Co.'s fire, that appeared in a Brussels newspaper. Americans were ever geniuses in experimental lines, but the Belgians do us more honor than we ourselves. This paper states that the city of New York possessed some new fire fighting apparatus that was supposed to be good, and in order to test it the Home Life building was purposely fired. It also states that the building was but slightly damaged and will be ready for occupancy very soon.

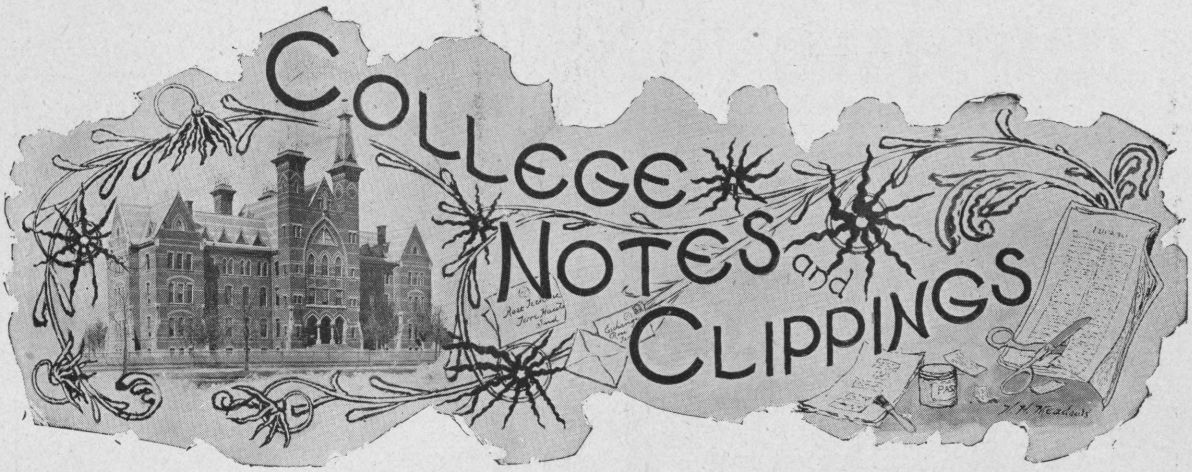
One way of defining a watt hour is to say that the energy represented by it is equal to that expended in raising a pound to a height of 2,654 feet or two watt hours correspond almost exactly to raising a pound to a height of one mile. Applying this to primary batteries gives results which at first sight are surprising. A certain dry battery, for instance, weighing 6,038 pounds yielded 130 watt hours, which, if applied to raising the battery itself, would lift it to a height of over 10 miles. In one hour the energy translated into an ordinary 16-cp. lamp weighing about an ounce, would raise that lamp to a height of 400 miles at a velocity of nearly seven miles per minute.—*Electrical World.*

Professor Howe is making some very interesting measurements upon the model steel swing bridge, recently constructed for the Civil department. There are a large number of disputed and unsolved questions relating to the stresses existing in the continuous girder, and theoretical stresses and deflections as calculated by the $\frac{\text{"}pul\text{"}}{E}$ formulæ of Professor Johnson. The model is a typical example of a well designed trussed continuous girder of two spans and a short turntable span. By means of movable loading and reaction measurements it is hoped to deduce results that will reconcile some of the present disputed points.

The new Senior hour plan for April will be purely laboratory work, proportioned as follows, and will require five and one-half days of ten hours each per week:

MECHANICALS AND ELECTRICALS.	
Shop Practice	38 hours
Engineering Laboratory	12 "
Physical Laboratory	5 "
Total	55 "
CIVILS.	
Civil Engineering	50 hours
Physical Laboratory	5 "
Total	55 "
CHEMISTS.	
Chemical Laboratory	50 hours
Physical Laboratory	5 "
Total	55 "

Professor Kendrick accounts for people not being luminous by the fact that they are not *hot* enough.



The women of Champaign edited the *Illini* of February 14, and the production indicated that it might be well to have a few women on the regular board. The general news was as well written as usual and the stories and verses were better.

The Indianapolis Gas and Water Companies have employed Mr. C. E. Brownell, of Dayton, Ohio, an electrical expert, to examine the pipes of that city for electrolytic effects. Grave fears are entertained because of the great network of pipes that exist.

The *Journal of the Association of Engineering Societies* for January, 1899, contains a memorial and portrait of Colonel Henry Flad, late member and President of the Engineer's Club of St. Louis, and papers on Cement Briquettes, by Prof. Jerome Sondericker, of the Boston Society of Civil Engineers; on Power and Equipment of Electric Railways, by Messrs. H. H. Hunt and C. K. Stearns of the same society; and a description of an electric railway from Butte to Centreville, Montana, by Mr. Francis W. Blackford, of the Montana Society of Engineers. All of these papers are illustrated.

In the *American Engineer* mention is made of the adaptation of water tubes to locomotive boilers on the London & Southwestern Railway. In this practice two nests of tubes are placed in the upper part of the fire-box sloping toward the sides, and 13 per cent. of the total heating surface of the boiler is in these tubes. There is no reason why this should not be extended, and it might possibly raise the remarkably low efficiency of this type of boiler. The water tube principle is employed in the boilers of torpedo boats, which work under conditions similar to locomotives, and there is some hope for an improvement in this direction.

James Swinburne, in *Electrical World*, describes a remarkable incandescent lamp invented by Prof. Nernst of University of Gottingen. In place of the ordinary filament, highly refractory oxides are worked up into rods and mounted on platinum wires. These oxides are exceptionly good insulators when cold but are electrolytes when hot, and the resistance decreases with the rise in temperature. The necessary instability in remaining in parallel is corrected with a fine wire series coil in the manner employed in arc lamps. Since the rods are insulators when cold they have to be heated with a match or spirit lamp to start the action, though in larger lamps heating coils are arranged in a shunt which is thrown out immediately the conductivity is established. The advantages of such a lamp are many. It can be made of any size and to suit any voltage. Power may be taken direct from mains at 500 volts and no transformer used, and by using double rods at 1,000 volts. The lamp requires absolutely no regulating machinery and no trimming. So soon as some better means is devised for the initial heating the Nernst lamp will very probably come into strong favor.